Express Mail No.: EV355034639US

APPLICATION FOR UNITED STATES LETTERS PATENT

Title: **MULTICOMPONENT SPUNBOND FILAMENTS HAVING A MELT-PROCESSABLE SUPERABSORBENT POLYMER CORE**

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SPECIFICATION

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MULTICOMPONENT SPUNBOND FILAMENTS HAVING A MELT-PROCESSABLE SUPERABSORBENT POLYMER CORE

Field of the Invention

The invention relates generally to methods for manufacturing spunbond nonwoven webs and, more particularly, to methods for manufacturing spunbond nonwoven webs from multicomponent filaments incorporating a melt-processable superabsorbent polymer core.

Background of the Invention

Nonwoven webs and their manufacture from melt-processable thermoplastic polymers has been the subject of extensive development resulting in a wide variety of materials converted for numerous commercial and consumer applications, such as disposable hygienic articles. Nonwoven webs consist of a sheet of overlapped and intermingled filaments or fibers of melt-processable thermoplastic polymers manufactured using, for example, spunbond processes. A spunbond process generally involves distributing one or more thermoplastic polymers in a spin pack for extrusion as a dense curtain of semi-solid filaments from a spinneret of the spin pack. The descending curtain of filaments is cooled by a cross-flow of cooling air and the individual

filaments are attenuated by a drawing device or aspirator. Spunbond filaments are generally lengthwise continuous and have average diameters in the range of about 10 to 20 microns. The filaments discharged from the drawing device are deposited on a collector, such as a forming belt or a forming drum, as a continuous length nonwoven web, which is slit and shaped for use.

Disposable hygienic articles commonly incorporate an absorbent core containing a superabsorbent polymer (SAP) capable of absorbing several times its weight of aqueous body fluids while retaining the absorbed fluids under moderate pressure. SAP's contain water-insoluble, cross-linked chain molecules that are capable of forming a hydrogel when hydrated by aqueous body fluids. The degree of polymer crosslinking of the SAP affects the absorbent capacity and gel strength of the hydrogel. In a physical property tradeoff, an SAP having high gel strength generally possesses a low absorption capacity, and an SAP having a high absorption capacity typically possesses low gel strength. Generally, SAP's characterized by a low absorbent capacity are incapable of absorbing a sufficient amount of fluid for practical use in a disposable hygienic article. To be useful in a disposable hygienic article, the SAP must have adequately high absorption capacity and the hydrogels formed therefrom must have adequately high gel strength.

In a conventional arrangement, the absorbent core includes granules of SAP that are dispersed in a porous matrix of cellulose fibers. The swelling of the SAP granules occurs in such a way that a very high absorption rate is observed shortly after an aqueous body fluid is introduced. However, the swollen SAP granules tend to close the open spaces in the SAP-fiber matrix, which slows or prevents the entry of aqueous body fluids by reducing

porosity and permeability. Subsequent amounts of aqueous body fluids that can no longer penetrate into the interior of the absorbent core may leak from the hygienic article. As SAP granules embedded deeper in the absorbent core are shielded, the total storage capacity of the absorbent core is effectively reduced. This surface-limiting blocking phenomenon is particularly acute for low gel strength SAP's of high absorbency. Another disadvantage of conventional absorbent cores arises because the matrix of cellulose fibers is bulky, which conflicts with consumer demand for thin diapers. Yet another disadvantage of conventional absorbent cores is that the SAP granules tend to leak when a weight-bearing load is applied to the absorbent core.

It would be desirable, therefore, to arrange a superabsorbent polymer in an absorbent core of a hygienic article with a configuration that enhances the total storage capacity.

Summary

The invention provides a nonwoven web and a product formed using the nonwoven web each of which includes a plurality of multicomponent filament. Each filament features a liquid-permeable or liquid-pervious sheath region and a core region encased within the sheath region. The sheath region comprises a melt-processable thermoplastic polymer and the core region comprises a melt-processable superabsorbent polymer capable of absorbing liquid that penetrates through said sheath region to said core region. The nonwoven web may be used to fabricate products or articles, such as an absorbent core for a hygienic article.

In another aspect, the invention is directed to a method of manufacturing a nonwoven web that includes heating a thermoplastic polymer to a flowable state, heating a superabsorbent polymer to a flowable state, and combining the thermoplastic polymer and the superabsorbent polymer to form multicomponent filaments. Each multicomponent filament has a liquid-pervious sheath region including the thermoplastic polymer and a core region including the superabsorbent polymer. The filaments are collected to form a nonwoven web.

In accordance with the principles of the invention, the superabsorbent polymer (SAP) in the core of the multicomponent filaments is mechanically strengthened by the presence of the sheath of liquid-pervious or liquid-permeable thermoplastic polymer. This strengthening permits the SAP to be characterized by lower gel strength and, therefore, a higher absorbency than in conventional absorbent cores for hygienic articles and other fluid-absorbing items featuring SAP granules dispersed in a cellulose fiber matrix. Because the SAP is confined in the core of the multicomponent filaments, the effect of surface-limited blocking on liquid absorption is significantly reduced and the SAP is more efficiently utilized for absorbing liquids. As compared with absorbent cores of conventional SAP-fiber matrices, an absorbent core including the multicomponent filaments of the invention requires a reduced amount of SAP to achieve an equivalent total storage capacity. Therefore, the absorbent core may be manufactured at a reduced cost. By eliminating the matrix of cellulose fibers found in conventional absorbent cores, hygienic articles and other fluid-absorbing items may be made thinner. The polymer

sheath surrounding the SAP core also assists for preventing leakage under a weight-bearing load.

These and other objects and advantages of the present invention shall become more apparent from the accompanying drawings and description thereof.

Brief Description of the Figures

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and, together with a general description of the invention given above, and the detailed description given below, serve to explain the principles of the invention.

Fig. 1 is a side view of a spunbonding apparatus for forming a plurality of filaments in accordance with the principles of the invention;

Fig. 2 is a perspective view of a portion of a multicomponent spunbond filament formed by the spunbonding apparatus of Fig. 1;

Fig. 3 is a cross-sectional view of the multicomponent spunbond filament of Fig. 2;

Fig. 4 is a cross-sectional view of a portion of a multicomponent spunbond filament in accordance with an alternative embodiment of the invention;

Figs. 5A and 5B are cross-sectional views of a portion of an alternative embodiment of a multicomponent spunbond filament in accordance with the principles of the invention;

Fig. 6 is a cross-sectional view similar to Fig. 4 of a portion of a multicomponent spunbond filament in accordance with an alternative embodiment of the invention; and

Fig. 7 is a perspective view of a hygienic article having an absorbent core including multicomponent spunbond filaments in accordance with the principles of the invention.

Detailed Description of the Preferred Embodiments

The invention is directed to methods for boosting the effectiveness of superabsorbent polymers (SAP's) used for absorbing large quantities of aqueous body fluids. To that end, the SAP is incorporated as a core region of multicomponent spunbond filaments encased in a porous thermoplastic polymer sheath. Although the filaments will be described herein as being formed using an exemplary meltspinning apparatus, it should be understood that modifications to the exemplary meltspinning apparatus described herein could be made without departing from the intended spirit and scope of the invention.

With reference to Fig. 1, a spunbonding apparatus 10 is equipped with a screw extruder 12 that converts a solid melt-processable polymer into a molten state and transfers the molten polymer under pressure to a set of metering pumps 16. Another screw extruder 14 converts another solid melt-processable polymer into a molten state and transfers the molten polymer under pressure to a set of metering pumps 18. Pellets of the solid polymers are placed in hoppers 11, 13 and fed to the corresponding one of screw extruders 12, 14 for melting and transfer.

Each set of metering pumps 16, 18 pumps metered amounts of the corresponding polymers at corresponding volumetric flow rates to a spin pack 20, which contains flow passageways that cooperate for combining the polymers. Spin packs are familiar to persons of ordinary skill in the art and, therefore, are not described here in detail. Generally, spin pack 20 includes flow passageways arranged to separately direct the polymers to a spinneret 22, in which the polymers are combined. The spinneret 22 includes spinning orifices (not shown) arranged in rows from which a dense curtain of filaments 24 each constituted collectively by the two polymers is discharged. An exemplary spin pack 20 is disclosed in U.S. Patent Number 5,162,074, the disclosure of which is hereby incorporated by reference herein in its entirety. The shape of the spinning orifices in spinneret 22 can be selected to accommodate the cross-section desired for the extruded filaments 24, such as round, oval, trilobal, triangular, dog-boned, or flat.

The descending curtain of filaments 24 is quenched to accelerate solidification by a cross-flow of cooling air from a quench blower 25. The filaments 24 are drawn into a filament-drawing device 26 that directs high velocity sheets of process air in a downwardly direction generally parallel to the length of the filaments 24. Because the filaments 24 are extensible, the converging, downwardly-directed sheets of high-velocity process air apply a downward drag that attenuates the filaments 24. Other exemplary filament-drawing devices 26 are disclosed in U.S. Patent Application Serial No. 10/072,550, U.S. Pat. No. 4,340,563, and U.S. Patent No. 6,182,732, the disclosures of which are hereby incorporated herein by reference in their entirety.

The filaments 24 discharged from filament-drawing device 26 are propelled toward a formaminous or porous collector 28, such as a moving screen belt. The filaments 24 deposit in a substantially random manner as substantially flat loops on the collector 28 to collectively form a nonwoven web 30. The collection device 28 moves in a machine direction, represented by the arrow labeled MD, parallel to the length of the nonwoven web 30. The width of the nonwoven web 30 deposited on collector 28 is substantially equal to the width of the curtain of filaments 24.

An air management system 32 positioned below the collector 28 supplies a vacuum that is transferred through the collector 28 to attract the filaments 24 onto the collector 28. The air management system 32 disposes of the high-velocity process air discharged from the filament drawing device 26 so that filament laydown is relatively undisturbed. Exemplary air management systems 32 are disclosed in U.S. Patent Number 6,499,982, the disclosure of which is hereby incorporated by reference herein in its entirety.

Additional spunbonding apparatus, not shown but similar to spunbonding apparatus 10, and meltblowing apparatus (not shown) may be provided downstream or upstream of spunbonding apparatus 10 for depositing one or more additional spunbond and/or meltblown nonwoven webs of either monocomponent or multicomponent filaments either as a substrate for receiving nonwoven web 30 or onto nonwoven web 30. An example of such a multilayer laminate in which some of the individual layers are spunbond and some meltblown is a spunbond/meltblown/spunbond (SMS) laminate made by sequentially depositing onto a moving forming belt first a spunbond fabric layer,

then a meltblown fabric layer and last another spunbond layer containing filaments 24.

With reference to Figs. 2 and 3 and in accordance with the principles of the invention, filaments 24 are multicomponent filaments including a sheath 34 of a melt-processable thermoplastic polymer concentrically surrounding a core 36 formed from a melt-processable SAP, including but not limited to acrylate-based materials such as polyacrylate or, more specifically, sodium polyacrylate which is a sodium salt of polyacrylic acid. The thermoplastic polymer forming sheath 34 may be selected from among any commercially available spunbond grade of a wide range of polymer resins, copolymers, and blends of polymer resins, including, without limitation, polyolefins, such as polyethylene, polypropylene, nylons, polyamides, polyesters, polyvinyl acetate, polyvinyl chloride, polyvinyl alcohol, and cellulose acetate. The core 36 may be concentrically arranged with the sheath 34 as depicted in Figs. 2 and 3 or, alternatively, may be eccentric or offset from the sheath axial centerline. The core 36 may also be distributed in multiple isolated cores within sheath 34 in an islands-in-the-sea configuration.

The sheath 34 is pervious or permeable to liquids or hydrophilic so that liquids can penetrate to the core 36 for absorption by the constituent SAP. The sheath 34 provides a mechanical support that strengthens the core 36 after an amount of a liquid is absorbed to form a hydrogel. As a result, a low gel strength and high absorbency SAP may be used in the core 36 of filament 24 for boosting the total storage capacity for liquids. Specifically, the SAP in the core 36 may exhibit an absorbency exceeding about 50 grams of saline per gram of SAP. Absorbency is a measure of the mass or volume of fluid that a

given amount of SAP will absorb before saturation. Gel strength indicates the tendency of the hydrogel, once formed from the SAP, to deform or flow under an applied pressure or stress. The recipe or chemistry of the SAP may be altered to increase or decrease the rate of absorption while maintaining a high absorbency. Increases or decreases in the thickness of the sheath 34 may be used to regulate the absorption rate of the SAP core 36. Typically, the filaments 24 contain at least about 50% by weight of SAP. The SAP in core 36 forms a hydrogel that expands volumetrically after absorbing liquid. As a result, filament 24 will expand in a radial dimension after liquid absorption. The SAP in core 36 retains the absorbed liquids under moderate applied pressures.

With reference to Fig. 4 in which like reference numbers refer to like features in Fig. 3, a sheath 38 of filament 24 may be formed under melt-spinning conditions such that an outer surface includes multiple pathways 40 each extending radially through the sheath thickness. The pathways 40 are direct passageways penetrating the sheath 38 and may be present as fractures in the sheath 38. Alternatively, the pathways 40 may include a plurality of interconnecting interstices that communicate with the outside and inside of the sheath 38. Because of the presence of pathways 40, liquids are able to more readily permeate or pervade the sheath 38 with a higher permeation rate and reach the SAP core 36 more efficiently for absorption.

The pathways 40 are introduced into the sheath 38 by various different techniques including, but not limited to, adding a pathway-promoting agent to the polymer of the sheath 38. In certain embodiments of the invention, the pathways 40 may be introduced in sheath 38 by conventional phase separation methods. For example, the pathways 40 may be formed by mixing

the thermoplastic polymer with a diluent or plasticizer, quenching in a liquid medium to induce phase separation, and washing away the diluent to leave behind an interconnected porous structure. Pathways 40 may also be formed in sheath 38 by introducing a blowing agent or a swelling agent into the thermoplastic polymer before the filaments 24 are formed. Another technique for forming pathways 40 in sheath 38 is to add a filler material, such as a concentration of particulate filler like calcium carbonate, capable of initiating pathway formation to the sheath polymer. Alternatively, pathways 40 may be introduced into the polymer forming sheath 38 by introduction of an additive, such as polyethylene glycol as disclosed in U.S. Patent No. 6,623,853, the disclosure of which is hereby incorporated by reference herein in its entirety.

With reference to Figs. 5A and 5B, filament 24 may be meltspun under conditions that form a central, axially-extending lumen in which the SAP is distributed in discrete, spaced-apart portions 42 surrounded by a sheath 44. Adjacent portions 42 are separated by one of multiple axially-extending voids 46. When liquid is absorbed, the portions 42 expand volumetrically or swell to at least partially fill the axially-extending voids 46, as shown in Fig. 5B, which reduces the volume of the voids 46. The portions 42 may be arranged with regular axial spacing or may have a less periodic arrangement. The arrangement consisting of portions 42 of SAP separated by voids 46 may be formed by controlling the relative volumetric flow rates of sheath polymer and SAP to the spin pack, such as spin pack 20 (Fig. 1) so that the flow rate of the sheath polymer is less than a flow rate required to has a structure in which the SAP core is uninterrupted by voids.

With reference to Fig. 6, filament 24 may include a core 48 constituted by an SAP matrix 50 containing SAP granules 52 and/or SAP agglomerates 54 and a sheath 56 surrounding the core 48. The effect of the dispersion of SAP granules 52 or SAP agglomerates 54 in the SAP matrix 50 is to increase the gel strength at the expense of a slight reduction in absorbency. The SAP granules 52 or SAP agglomerates 54 are added along with the solid-phase SAP to the appropriate one of the hoppers 11, 13 (Fig. 1).

With reference to Fig. 7, a disposable hygienic article 58 generally includes a top sheet 60, a back sheet 62, an absorbent core 64 separating the top sheet 60 from the back sheet 62, and a fluid acquisition and transfer layer 66 separating the absorbent core 64 from the top sheet 60. The top sheet 60, which is intended to be placed adjacent to the wearer's skin when the hygienic article 58 is worn, is fluid pervious so that aqueous body fluids may readily penetrate through its thickness to the absorbent core 64. Fluid acquisition and transfer layer 66 distributes aqueous body fluids transferred from top sheet 60 to the underlying absorbent core 64. The nonporous, hydrophobic back sheet 62 prevents aqueous body fluids absorbed in the absorbent core 64 from wetting the wearer's clothing, such as pants, pajamas and undergarments. Fastener elements 68 on the back sheet 62 cooperate with complementary fastener elements 70 on corresponding attachment tabs 72 extending laterally from the back sheet 62 for attaching the hygienic article 58 to a wearer.

The absorbent core 64 includes filaments 24 in accordance with the principles of the invention capable of absorbing large quantities of aqueous body fluids and retaining the absorbed body fluids under moderate applied pressures. The absorbent core 64 may be formed in its entirety from filaments

24, from a commingled mixture of filaments 24 and other non-absorbent spunbond filaments, or from a multi-ply laminate structure in which nonwoven web 30 forms one layer. The absorbent capacity of the absorbent core 64 may be optimized for the intended use of the hygienic article 58.

After a limited number of soilings by aqueous body fluids is absorbed by the absorbent core 64, the hygienic article 58 is intended to be discarded. The invention contemplates that hygienic article 58 may be any item used to absorb and contain aqueous body fluids, and more specifically refers to devices that are placed against or in proximity to the body of the wearer to absorb and contain the various aqueous body fluids discharged from the wearer. For example, hygienic article 58 may be a diaper, a catamenial pad, a feminine hygiene product such as tampons and sanitary napkins, absorbent underpants, an incontinence pad, a training pant and the like, as well as a wipe, a bandage, a wound dressing, and other articles. The invention contemplates that various other consumer and commercial articles or applications that require a heightened level of liquid absorption may incorporate the multicomponent filaments 24 of the invention. As examples, the multicomponent filaments 24 of the invention may be used to for protecting power and communication cables from moisture, in agriculture to increase the capability of soil to retain moisture and nutrients, for treating and containing wastewater, and in the hygienic packaging of food products.

While the present invention has been illustrated by a description of various embodiments and while these embodiments have been described in considerable detail, it is not the intention of the applicant to restrict or in any way limit the scope of the appended claims to such detail. Additional

advantages and modifications will readily appear to those skilled in the art. The invention in its broader aspects is therefore not limited to the specific details, representative apparatus and methods, and illustrative examples shown and described. Accordingly, departures may be made from such details without departing from the spirit or scope of applicant's general inventive concept. The scope of the invention itself should only be defined by the appended claims, wherein I claim: